Patulous Eustachian Tube Identification Using Tympanometry

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Abstract
The patulous, or nonclosing, eustachian tube is believed to affect as many as 7 percent of all adults, causing physical and psychological difficulties. This paper provides a brief review of the literature regarding the patulous eustachian tube (PET), its symptoms, precipitating conditions, incidence, diagnosis, and current medical management. Several case studies are also presented to illustrate the use of tympanometry in PET identification.

Key Words: Patulous eustachian tube, tympanometry

Problems associated with failure of the eustachian tube to open are well known and have been the subject of considerable research (e.g., Bluestone and Doyle, 1985). However, problems related to the failure of the eustachian tube to close have received much less attention. Yet patulous, or nonclosing, eustachian tubes can cause physical and psychological problems (Pulec and Simonton, 1964), and may be present in a sizeable part of the clinical population (O'Conner and Shea, 1981). The purpose of this paper is to provide a brief tutorial and several cases as examples of normal and patulous eustachian tube (PET) function.

CLINICAL FACTORS OF PATULOUS EUSTACHIAN TUBE

Symptoms
The most common PET symptom is a feeling of aural fullness and/or a plugged or blocked ear. Unfortunately, this is also a common complaint of persons experiencing a variety of middle and inner ear disorders. Auditory symptoms include the report of autophony, or the phenomenon of being able to hear one's own voice more loudly than usual, and hearing a loud crackling sound when chewing. Robinson and Hazell (1989) reported that vestibular symptoms and hearing loss can also occur because the PET allows excessive pressure changes to occur in the middle ear which are then transmitted to the inner ear through ossicular movement. They reported reducing vestibular symptoms in five of six patients by treatment of their PET condition. We have encountered two PET patients with little or no hearing loss who complained of difficulty hearing, presumably due to the masking effects of sound transmitted via the eustachian tube to the middle ear. PET symptoms can either be continuous or episodic, occurring in one or both ears, and typically diminishing or disappearing when the patient is supine (O'Conner and Shea, 1981). Pulec and Simonton (1964) reported that patients can be so disturbed by PET symptoms that they give the impression of being "psychoneurotic."

Etiology
Factors that may influence the occurrence of a PET include sudden weight loss, hormonal changes (e.g., as in pregnancy or use of birth control pills), stress, fatigue, the inappropriate use of decongestants, and temporomandibular joint (TMJ) syndrome (O'Conner and Shea, 1981).
Prevalence

The prevalence of PETs is not well known. Munker (1980) reported finding a PET in 6 percent of a group of 100 female patients "with normal ears" in one study, and 6.6 percent of 181 persons "with normal hearing" in a second study. Plate et al (1979), identified a PET in 28 of 270 (10%) pregnant women tested. Kumazawa (1985a) found that 30 percent of 100 "normal ears" tested had abnormally patent eustachian tubes.

The reports of prevalence contrast with the small number of people diagnosed by physicians as having a PET. Pulec and Simonton (1964) reviewed the records of the Mayo clinic from 1940 to 1959 and found 41 diagnoses of PET. Munker (1980) estimated that only 10 to 20 percent of all persons with PET are bothered enough by the symptoms to seek medical attention, while O'Connor and Shea (1981) concluded that PETs were frequently misdiagnosed because their symptoms were very similar to serious otitis.

Diagnosis

Diagnosis of a PET by the physician is usually made through a combination of history and otoscopic or microscopic examination of the tympanic membrane (TM). It is usually possible to observe TM movements occurring synchronously with inspiration and expiration; the result of transmission of intraoral air pressure changes to the middle ear through the patent eustachian tube.

Use of Tympanometry in Identification

Although not common in audiology literature, the use of tympanometry to identify PETs is not new (Metz, 1953; Bluestone, 1975; Rock, 1976; Kumazawa, 1985a, b). Kumazawa (1985b) described three methods for using acoustic impedance for evaluating eustachian tube function. Bluestone (1975), Rock (1976), and Martin (1991) all recommended asking the subject to breathe through their nose while a tympanogram was obtained. The resulting tympanogram, when printed, would show superimposed fluctuations in impedance occurring synchronously with the patient's respiratory cycle. Plate et al (1979) used a Madsen ZO-70 impedance bridge with the sensitivity selector in position "2" (slightly more sensitive than the setting for obtaining a tympanogram) in their study of pregnant women. With the patient breathing through her nose, they noted the occurrence of impedance changes synchronous with respiratory cycles. They did not specify the amount of change necessary to indicate a PET. Kumazawa (1985a) used a tympanometer modified to measure impedance changes simultaneously with changes in nasopharyngeal pressure. Patients were instructed to first perform a valsalva maneuver, establishing a higher than normal middle ear pressure, then swallow several times, equalizing middle ear with ambient pressure. Kumazawa labeled eustachian tube function as "normal" when middle ear pressure was restored to normal with several swallows, "occluded" when pressure failed to return to normal, and "patent" or "patulous" when middle ear pressure immediately returned to normal without the need for swallowing.

All of the above methods for identifying PETs with tympanometry have been reported either in the medical research literature or in books devoted to immittance testing. We are aware of only one audiology textbook (Martin, 1991) that briefly describes PETs and the use of impedance in identification of PETs.

Treatment

Fortunately, PETs are frequently transient, resolving when the condition causing them (e.g., weight loss or hormonal changes) resolves (Pulec and Simonton, 1964; Bluestone and Cantekin, 1981). When PET is a chronic problem requiring medical intervention, several methods of treatment have been reported; none have been shown to be effective in all cases. Methods of treatment attempted over the years include boric acid/salicylic acid insufflation at the pharyngeal opening of the eustachian tube; cauterization with silver nitrite or diathermy; injection of paraffin, gelatine sponge, or Teflon; myringotomy and insertion of ventilating tubes; and surgical alteration of the palatal muscles (Misurya, 1974; Robinson and Hazell, 1989). Bluestone and Cantekin (1981) recommend myringotomy and ventilating tubes in conjunction with insertion of a small plugged catheter in the middle ear end of the eustachian tube. While all of the above methods have had some success, we have found no consensus in the literature as to which is the best method of treatment. We are currently experimenting with drops, which can be applied nasally by the patient when a PET condition is experienced. Early results with a few patients have been promising and a larger study is now in progress.
Because PETs occur in a sizeable portion of the population and coverage of this phenomenon is sparse in the audiology literature, the following case studies are presented to heighten audiologists' and physicians' awareness of PETs. The patients in the following four case studies were part of an ongoing study (DiBartolomeo and Henry, 1992) of the effectiveness of a new method of treating PETs.

**CASE STUDIES**

Patients were referred for tympanometry after an otolaryngological examination revealed historical or physical indications of a possible PET in at least one ear. Immittance tympanometry was performed on all patients using a Virtual Model 310 Digital Impedance System controlled by a Macintosh SE/30 microcomputer. All patients were tested according to the following protocol.

With the patient seated, testing was performed with the probe in one ear first, then in the other ear. The order of ears tested was not controlled. Prior to performing the PET test, tympanograms and acoustic reflexes were obtained to evaluate middle ear function.

The Virtual acoustic reflex adaptation test was used to test for PETs. In this test mode, up to four separate 20-second measures of admittance changes can be obtained and displayed on one graph. To prevent eliciting an acoustic reflex, which might obscure subtle admittance changes, a contralateral stimulus was presented at 60 dB HL, the lowest intensity possible with this system. Three 20-second measures of admittance change were obtained under three different breathing conditions. During the first condition, the patient was instructed to sit quietly, breathing through the mouth or not at all, while a 20-second baseline measure was obtained. The baseline served two functions. The first was to provide a measure of TM admittance changes when little or no nasopharyngeal pressure changes were occurring. The second purpose of the first condition was to ascertain that the acoustic reflex stimulus tone was not eliciting a reflex response. We observed no admittance changes that occurred as a result of the relatively low intensity contralateral stimulus in any patient.

During the second condition, the patient was instructed to breathe in and out through the nose as deeply as possible when the examiner indicated. Patients usually performed three forced respiration cycles in the 20-second period. During the third condition, the patient was instructed to close one nostril with a finger and repeat the forced respiration cycles when asked, as in the second condition. Closing one nostril and performing forced breathing was requested to increase the nasopharyngeal pressure changes, thereby accentuating the effects of a PET, if one was present.

**Case 1**

Figure 1 represents the right and left ear admittance changes (in mmhos) of a 21-year-old female. The top line for each ear represents the admittance changes seen during the baseline condition of quiet respiration through the mouth. The middle line for each ear represents admittance changes during forced respiration through both nostrils. The bottom line for each ear represents admittance change during forced respiration through one nostril. No change in admittance synchronous with breathing occurred, indicating a middle ear system with a normally closed eustachian tube. This is consistent with a normal response to a PET test, bilaterally.

**Case 2**

Figure 2 shows the right and left ear admittance changes of a 38-year-old female. The right ear PET results are similar to the normal ear results shown in Figure 1. Left ear admittance changes for the forced respiration conditions were at least .05 mmhos, and occurred synchronously with each respiratory cycle. This patient was diagnosed as having a normally functioning right eustachian tube and a patulous left eustachian tube.
Case 3

Admittance changes from the left ear of a 33-year-old female are shown in Figure 3. In this case she held her breath for the first test and breathed quietly through the nose for the second test. The admittance changes during quiet breathing occurred synchronously with her respiratory cycles and were greater with forced respiration through one nostril. This patient has a history of chronic otitis media as an adult, which might seem paradoxical given her concurrent history of bilateral PETs. However, she has a habit of constantly sniffing, which created a negative pressure in the middle ear that helped to keep the eustachian tube closed and relieve her PET symptoms. We believe this precipitated build-up of fluid and infection, resulting in episodes of chronic otitis media, which this patient has had for several years. Sniffing in order to minimize symptoms has been reported by other investigators (Suehs, 1960; O'Conner and Shea, 1981).

Case 4

Figure 4 presents the right ear responses of an 18-year-old male during forced respiration through both nostrils. The patient reported having a temporomandibular joint (TMJ) problem and only experiencing PET symptoms when his jaw was in certain positions. The top line represents admittance changes with the jaw in a position in which no symptoms were experienced. The bottom line represents admittance changes when the jaw was deviated laterally to a position at which the patient reported increased PET symptoms.

Case 5

Figure 5 shows the right ear admittance changes of a 23-year-old female without PET symptoms. This patient was being tested as a normal subject and had a negative history of hearing loss or otologic problems. Admittance changes synchronous with respiration were obtained in all three conditions. Immediately after obtaining these results, visual examination of the tympanic membrane (TM) under microscope was performed. TM movement was observed, visually confirming bilateral PETs. Even after we identified the presence of PETs, this patient was not bothered enough by them to seek medical treatment.

This patient was one of five patients originally tested as a normal subject for vestibular research who also underwent PET testing. As part of the research protocol, each had under-
Right Ear: 23-year-old female.

Figure 5 Right ear admittance changes of a 23-year-old female with no complaints or reported symptoms of a patulous eustachian tube. Note admittance changes that occurred in conjunction with respiratory cycles during quiet breathing.

gone an initial otoscopic examination, and on a medical history questionnaire reported a negative history of hearing or balance problems, otitis media, or noise exposure. Of the five, two exhibited signs of a PET condition. A perplexing question for researchers is why some people are very aware of and upset by this condition while others are not.

DISCUSSION

These case studies were selected because they demonstrate both normal and abnormal responses, and represent some of the more common causes and complaints of the chronic PET condition. It should be noted that immittance testing is not diagnostic, it only indicates abnormal function. A positive PET immittance test in isolation should be followed up medically.

The case of the “normal” patient with no complaints demonstrates some of the perplexing questions regarding this condition. Why some patients exhibit the objective signs of a PET, yet do not complain of the subjective symptoms of the disorder is a question not yet answered.

We believe PET is underdiagnosed, and through greater physician and audiologist awareness, more cases will be identified. The results presented above demonstrate the role that audiologist and tympanometry can play in identifying PETs. While these results were obtained using a sophisticated computer controlled system, the test itself can be performed with most immittance equipment. Subjective complaints of poor hearing in conjunction with normal hearing sensitivity, fullness of the ears with normal tympanograms, and report of hearing voice and breathing more loudly than normal should trigger at least additional questioning by the audiologist or physician, and when appropriate, a PET test.


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REFERENCES


Patulous Eustachian Tube/Henry and DiBartolomeo